

Appendix C Graphics and Photographs

C-1. Introduction

This appendix contains diagrams, photographs, and brief descriptions of projects representative of the types of construction methods in this manual. Some of the projects are discussed in Appendix B.



Figure C-1. Radial gate structure under construction for the Montezuma Slough Salinity Barrier

C-2. Montezuma Slough Salinity Barrier

The Montezuma Slough Salinity Barrier was designed and constructed for the California Department of Water Resources to prevent saline water from moving up the Sacramento River from San Francisco Bay into the Montezuma Slough estuary. The radial gate structure, shown under construction in Figure C-1, was one of three float-in precast concrete structures that formed the barrier. The radial gate structure has three 11-m- (36-ft-) wide gates and is used to regulate water flow in the slough. The other two structures are a 20.1-m- (66-ft-) wide flashboard opening to allow for unrestricted vessel passage when the structure is not in operation; and a boat lock structure with a 6.1-m-wide by 21.3-m-long (20-ft-wide by 70-ft-long) lock chamber to allow passage of vessels when the flashboard opening is closed. The precast structures were fabricated in turn on a ground barge, then floated near the site on the barge, and then launched off

the barge by tilting the barge down. The structures were then floated to the site and sunk into position. The structure was completed in 1988 at a cost of approximately \$12.5 million versus an estimated cost of \$25 million for constructing the structure “in the dry.”

C-3. I-205 Columbia River Bridge

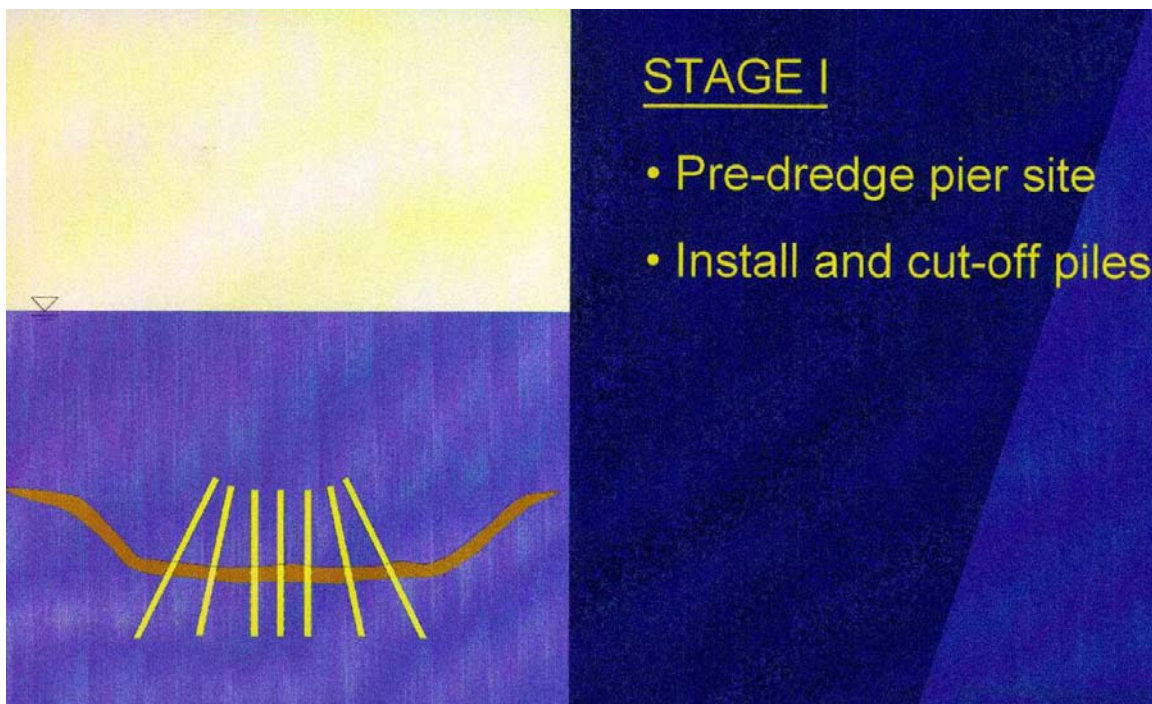
a. In Stage 1 (Figure C-2a) of the construction sequence for a typical pier for the I-205 Columbia River Bridge between Oregon and Washington, the pier site was first dredged and then H-piles were driven and cut off to the proper elevation. The H-piles were driven through a bottom-founded template that was floated into position to ensure accuracy of the pile positions.

b. In Stage 2 (Figure C-2b), a nominally 450-tonne (500-ton) capacity catamaran crane barge called the Super-Lift was used to install a preassembled reinforcing steel cage into a prefabricated pier form.

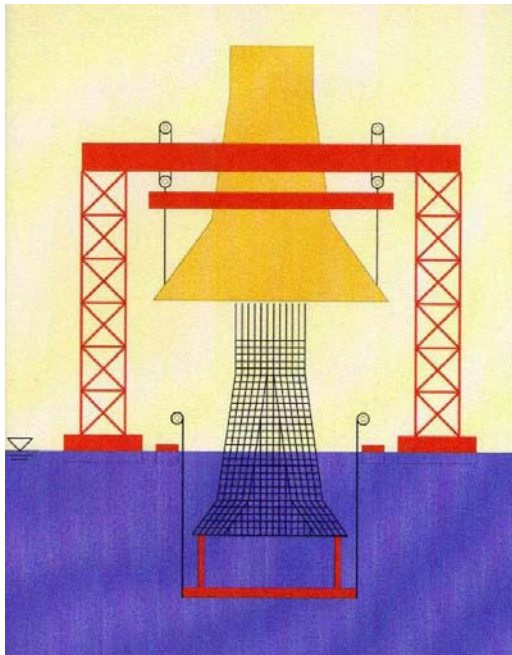
c. In Stage 3 (Figure C-2c) the form was then positioned over the predriven H-piles, and temporary spud piles were driven both to carry the load of the form and to act as a guidance system during installation.

d. In Stage 4 (Figure C-2d) the catamaran then lowered the form to grade, and the weight of the form was transferred to the spud piles in preparation for the tremie concrete placement operations.

e. In Stage 5, a 2.7-m- (9-ft-) thick tremie concrete seal pour was made (Figure C-2e). Then, the form was dewatered, the top of the concrete was cleaned, a bottom reinforcing mat was placed, and the remaining concrete was placed in the dry. Then the form was stripped in one piece and the spud piles were removed.



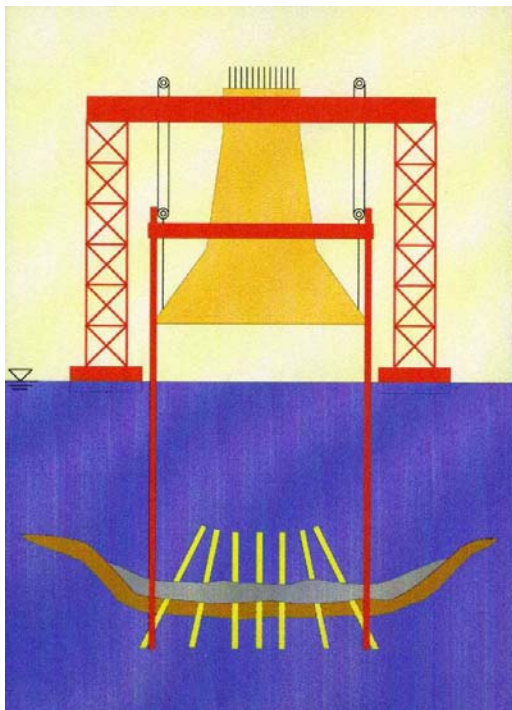
a. Stage 1
Figure C-2. Construction sequence for a typical pier for the I-205 Columbia River Bridge
(Sheet 1 of 3)



STAGE 2

- Pre-assemble pier form
- Pre-assemble reinforcing
- Install cage inside pier form

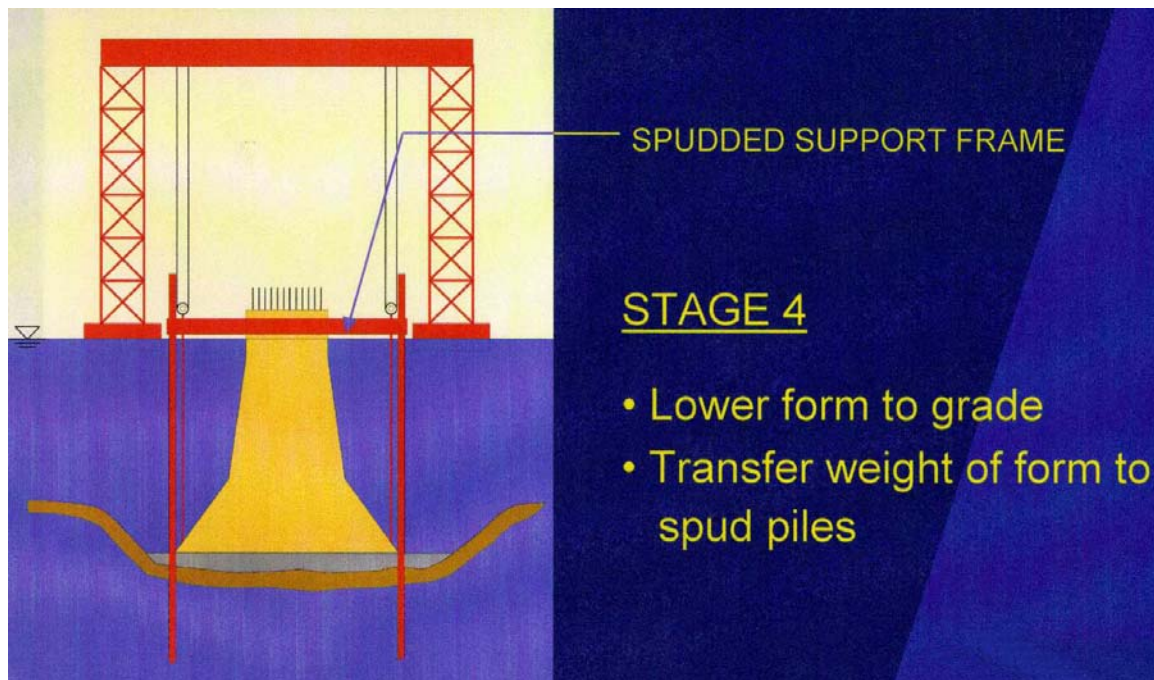
b. Stage 2



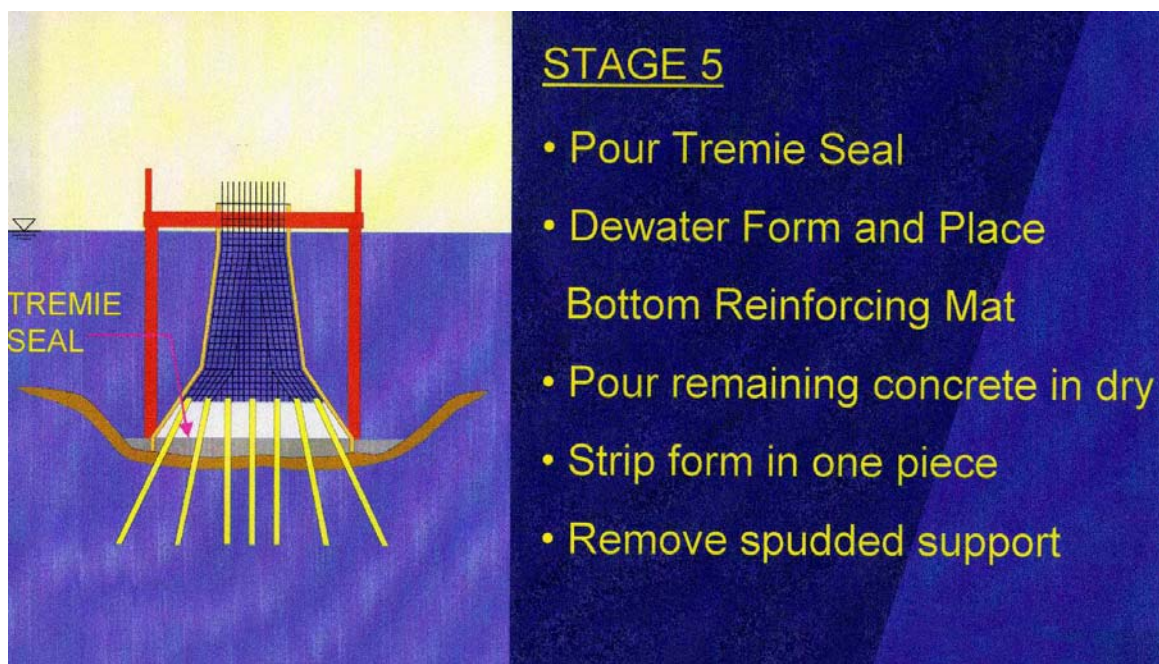
STAGE 3

- Position Form over Piling
- Drive temporary spud piles

c. Stage 3
Figure C-2. (Sheet 2 of 3)



d. Stage 4



e. Stage 5
Figure C-2. (Sheet 3 of 3)

C-4. Eastern Scheldt Storm Surge Barrier

The Eastern Scheldt (Oosterschelde) storm surge barrier (Figure C-3) was the last stage of the Netherlands' Delta project designed to protect the Dutch lowlands from the sea. The Eastern Scheldt storm surge barrier was designed with 62 hydraulically actuated lift gates so that normally water could circulate into the estuary and the gates would be closed only during periods of storm surge to prevent

flooding. The storm surge barrier is approximately 3 km (1.9 miles) long across three different tidal channels. It was completed in 1986. The site had a sandy foundation, which required vibro-densification, controlled dredging, and scour/piping protection by both sand/gravel-filled geotextile fabric and articulated concrete block mattresses. Following installation of the mattresses, the nominally 8,000-tonne- (8,800-ton-) capacity catamaran crane barge *Ostrea* lifted, transported, and placed on top of the mattresses partially buoyant prefabricated prestressed concrete pier shells that weighed up to 18,000 tonnes (19,840 tons).



Figure C-3. The Netherlands' storm surge barrier for the Eastern Scheldt

C-5. Prefabrication Facility Concept, Olmsted Dam

The feasibility level prefabrication facility shown in Figure C-4 is for the construction of precast concrete shells and associated items for the Olmsted Dam on the Ohio River. Although this facility is conceptual in nature, it exhibits several features that are important for the Olmsted Dam offsite prefabrication method:

- a. Land-based skidways that allow precast concrete shells weighing up to 3,630 tonnes (4,000 tons) to be stored and moved forward as needed.

b. A marine skidway that allows the shells to be moved down the riverbank into water at various river stages.

c. A deep-water site that allows the shells to be partially submerged so that a nominally 2,540-tonne- (2,800-ton-) capacity crane barge can lift up to 3,630-tonne (4,000-ton) shells.

d. Provisions for auxiliary functions such as concrete production, reinforcing steel cage assembly, mattress fabrication, and fleeting areas.

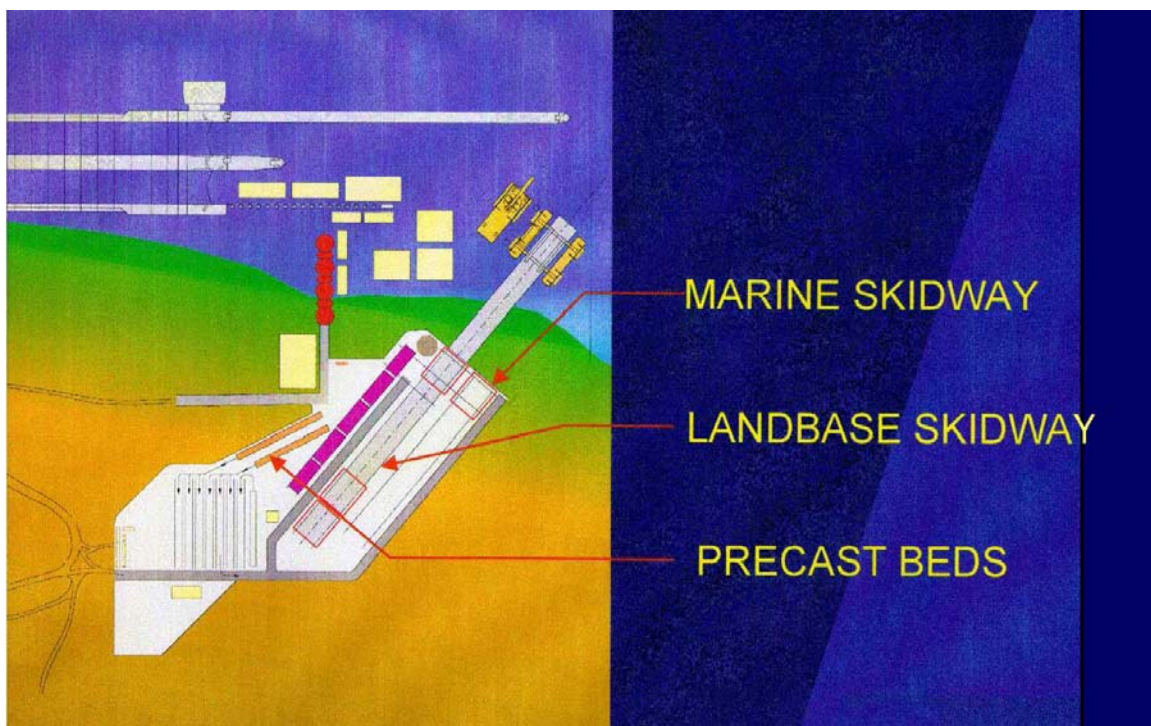


Figure C-4. Feasibility level layout of prefabrication facility for Olmsted Dam construction

C-6. Tremie Concrete Placement Concept, Olmsted Dam

The tremie concrete placement represented in Figure C-5 for the Olmsted Dam construction has several key aspects including the following:

- The tremie concrete is designed for low heat generation and uses blast furnace slag.
- The tremie concrete has good workability with a slump in excess of 254 mm (10 in.).
- Laitance from the tremie concrete is expelled through holes in the top of the shells.
- The tremie placement pattern is designed to reduce tremie concrete pressures on the shells, minimize the potential for the formation of voids in the tremie concrete, and assist with the placement of the tremie concrete from fixed points.

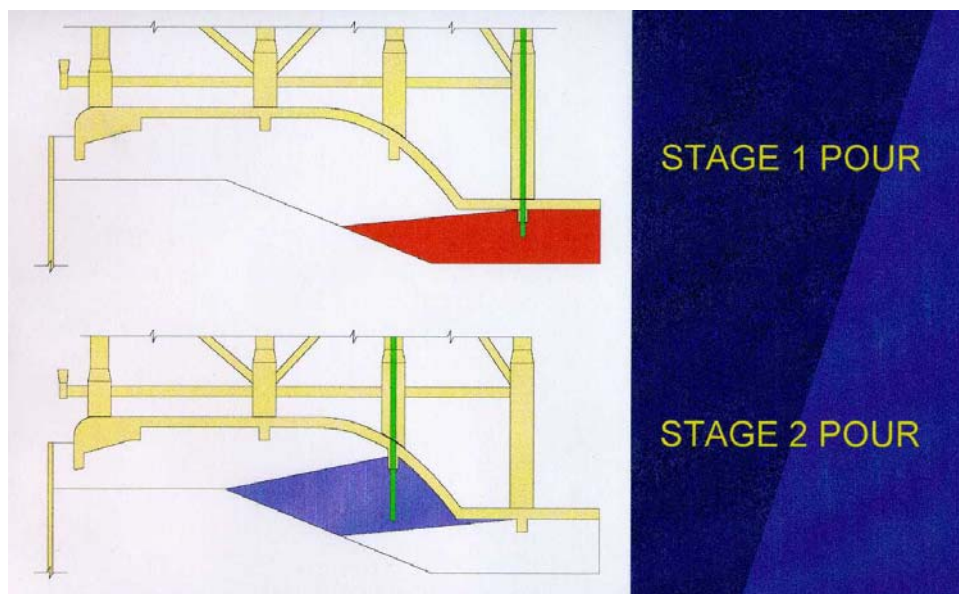


Figure C-5. Representative tremie concrete placements for Olmsted Dam

C-7. Wilbur Mills Dam

The Wilbur Mills Dam in Arkansas sustained severe damage to its stilling basin when floodwaters overtopped the dam. On an emergency basis, an in-the-wet method of repair was developed that used several used steel barges as stay-in-place forms for tremie concrete that was used together with preplace aggregate to fill the sunken barges. Figure C-6 shows how a nominally 1,450-tonne- (1,600-ton-) capacity catamaran crane barge was used to lower the barges weighted with concrete ballast to the bottom.



Figure C-6. Emergency repair operations for the Wilbur Mills Dam

C-8. Oresund Bridge

The Oresund Bridge crosses a strait in the Baltic Sea from Denmark to Sweden. The precast concrete caissons shown in Figure C-7 were cast in a graving dock. When the graving dock was flooded, a specialized catamaran crane barge floated over the caissons and lifted them, with the aid of self-buoyancy from the caissons, and transported them to the bridge site. Linear jacks on the catamaran were attached to the vertical pipes attached to the caissons (see Figure C-7). The rigidity of this lifting system helped to minimize the cross-bracing requirements for the catamaran.

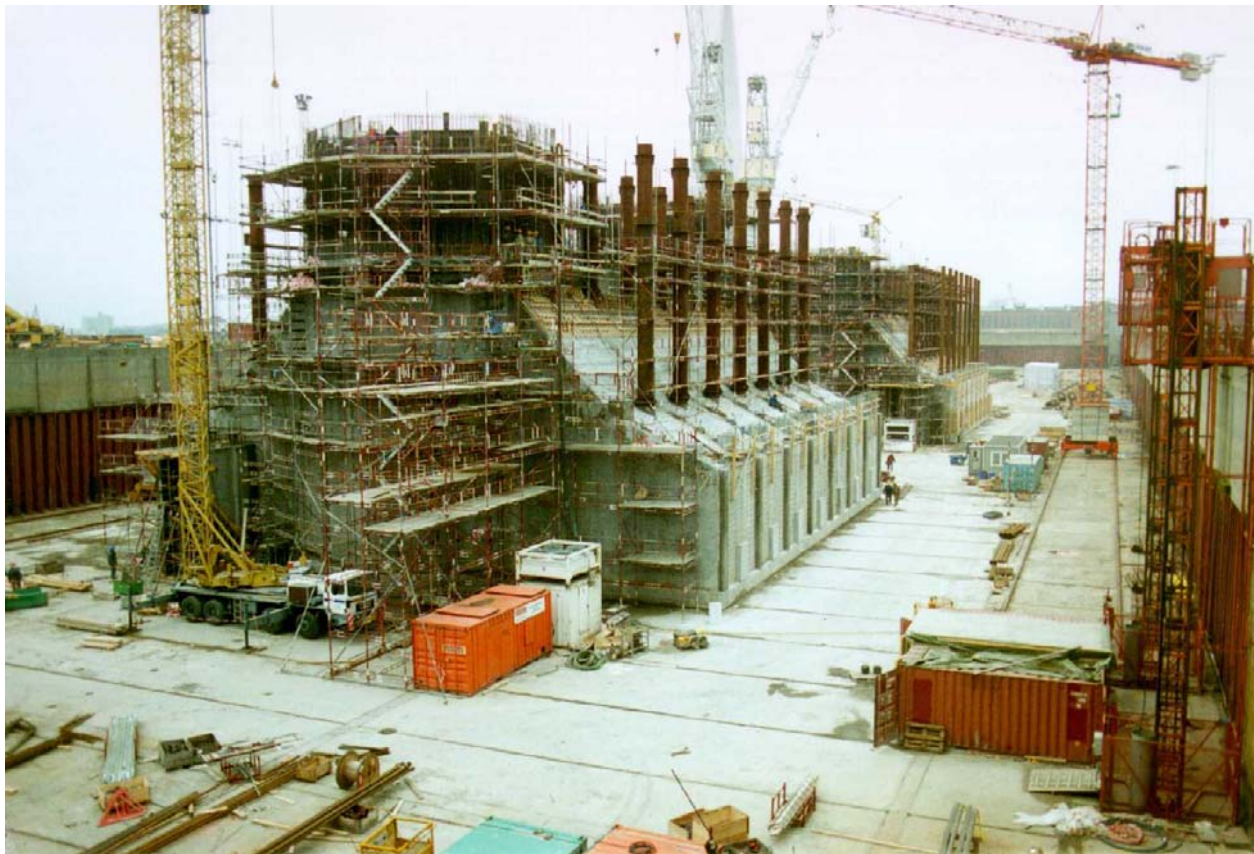


Figure C-7. Prefabrication of concrete bridge pier caissons for the Oresund Crossing

C-9. Immersed Tube Installation

The immersed, precast concrete tube segment shown in Figure C-8 illustrates several features typical of European-style designs and installation procedures, including the following:

- The tube segments typically use prestressed concrete with "Gina"-type rubber joint seals.
- Spotting towers are typically used to help locate the segments during submergence.
- Segmental pontoons are commonly used on top of the segments for both water plane stability and supplemental buoyancy during submergence.



Figure C-8. Typical European-style concrete immersed tube segment

C-10. Float-in, U-Frame Lock

The feasibility level concept shown in Figure C-9 for a float-in precast concrete lock extension was examined during a study for the Upper Mississippi River and Illinois Waterway System Navigation Study. For many of the locks in this area it is not feasible to shut down the single existing lock for an extended period while the lock is being extended. Key features of this concept are as follows:

- The U-shaped hull results in a stiff structure that can resist variations in water head with a minimum of lateral stiffness from the foundation.
- Once the foundations are complete, the entire lock extension can be floated in, set down, and stabilized in as little as a day.
- The individual segments composing the whole lock extension can be joined afloat to minimize the size of the offsite prefabrication facilities.

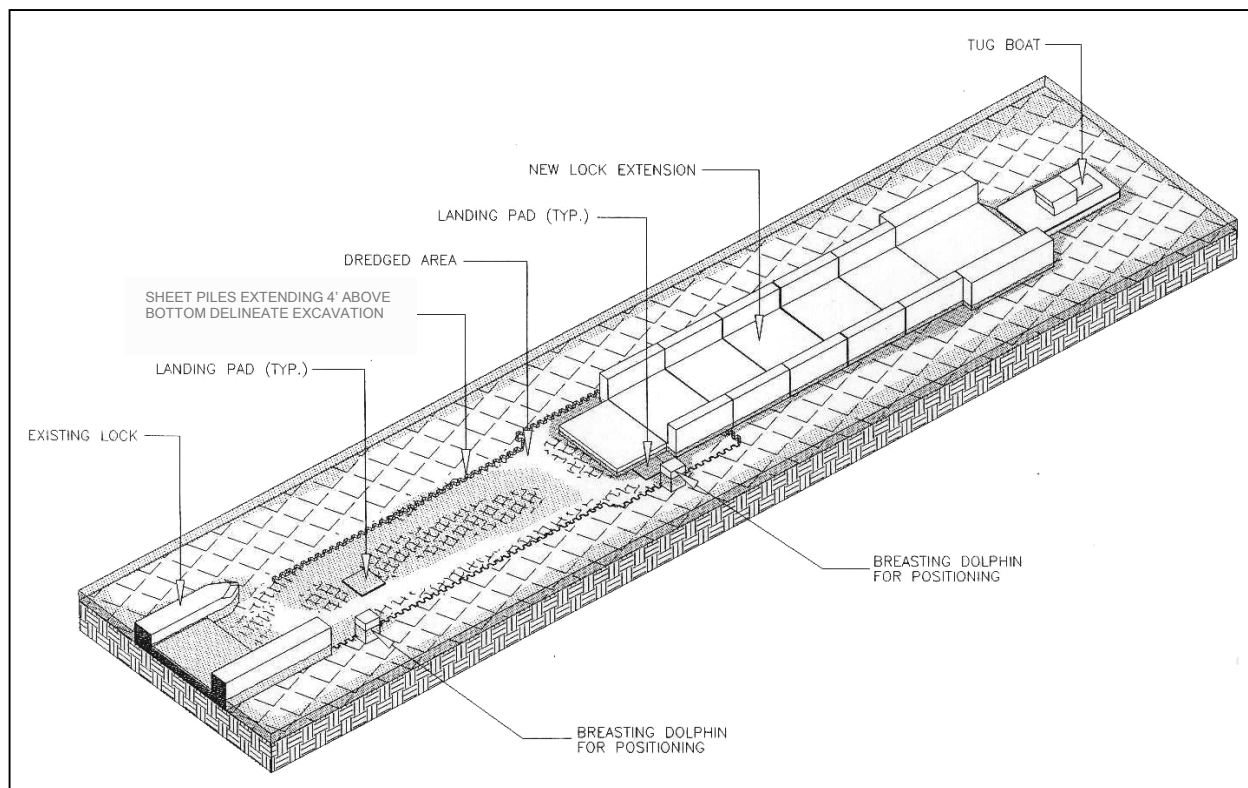


Figure C-9. Representation of a float-in U-shape concrete hull for a lock extension

C-11. Braddock Dam

a. Figure C-10 shows the offsite prefabrication of the Braddock Dam segments. This method of construction is designed to accommodate variations in river stage, while minimizing excavation and reducing the effects/delays from long-term flooding of an alternative such as a graving site. The casting basin is built in two levels so that the segments are built at the upper level. The casting basin is then flooded so that the segment can float over the lower level, where the water level is brought into equilibrium with the river stage, and the closure gate is removed so that the segments can be towed to the site.

b. Figure C-11 shows two images of segment assembly at the casting facility. Over 400 precast concrete panels were manufactured on this site and connected to form the walls of the two float-in dam segments. The bottom and top slabs of the segments and the joints between panels were completed with cast-in-place concrete placements. A combination of lightweight and normal-weight concrete was used to conserve weight for draft requirements.

c. Figure C-12 shows float-in dam segment transport along the inland waterways navigation system. The float-in segments were transported 43 km (27 miles) from the casting facility to the project site. The segments were appropriately sized to allow lockage through existing facilities.

d. Figure C-13 shows positioning of the float-in dam segment for Braddock Dam on the Monongahela River in Pennsylvania. A preinstalled mooring/positioning system further helps to control positioning of the units during the set-down operations.

e. Figure C-14 depicts a light lift-in approach used for completion of the Braddock Dam tailrace. Thirty-one panels weighing up to 60 tonnes (65 tons) complete the new dam tailrace. A program of tremie

concrete infill provides for a solid mass beneath the panels. All installations were controlled with dive crews.

f. Figure C-15 shows the one-piece float-in installation of a tainter gate. This application varied from traditional methods in that field-assembled pieces of the gates were constructed within a dewatered gate bay.



a. Prefabrication site, Leetsdale, PA



b. Float-out or launch of the first segment of the dam
Figure C-10. Braddock Dam Casting Facility



a. Construction of dam Segment 1 within the two-level casting basin



b. Construction of dam Segment 2 within the two-level casting basin
Figure C-11. Assembly of float-in Braddock Dam at casting facility



a. Open-river transport of a dam segment



b. River miles from fabrication site to outfitting dock
Figure C-12. Segment transport of Braddock Dam



a. Initial positioning of dam Segment 1



b. Close-up of initial positioning of dam Segment 1
Figure C-13. Positioning of the first segment for Braddock Dam



Figure C-14. In-the-wet tailrace panel installation for Braddock Dam

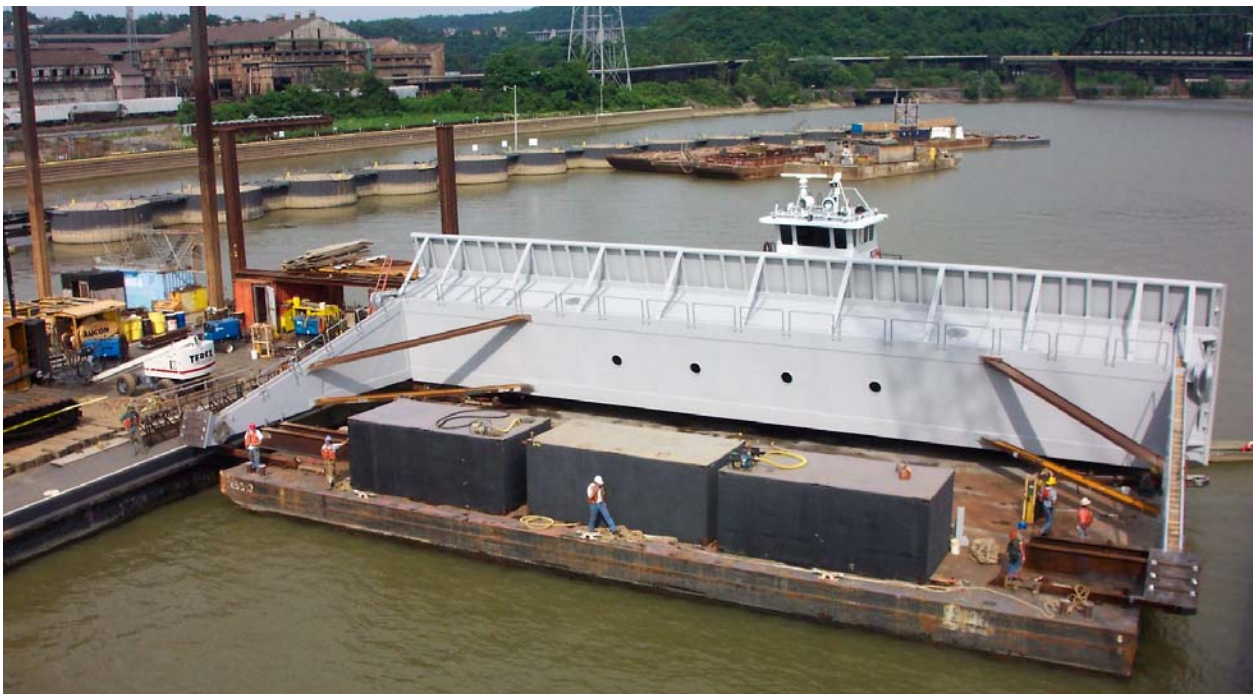


Figure C-15. One-piece float-in installation of tainter gate for Braddock Dam

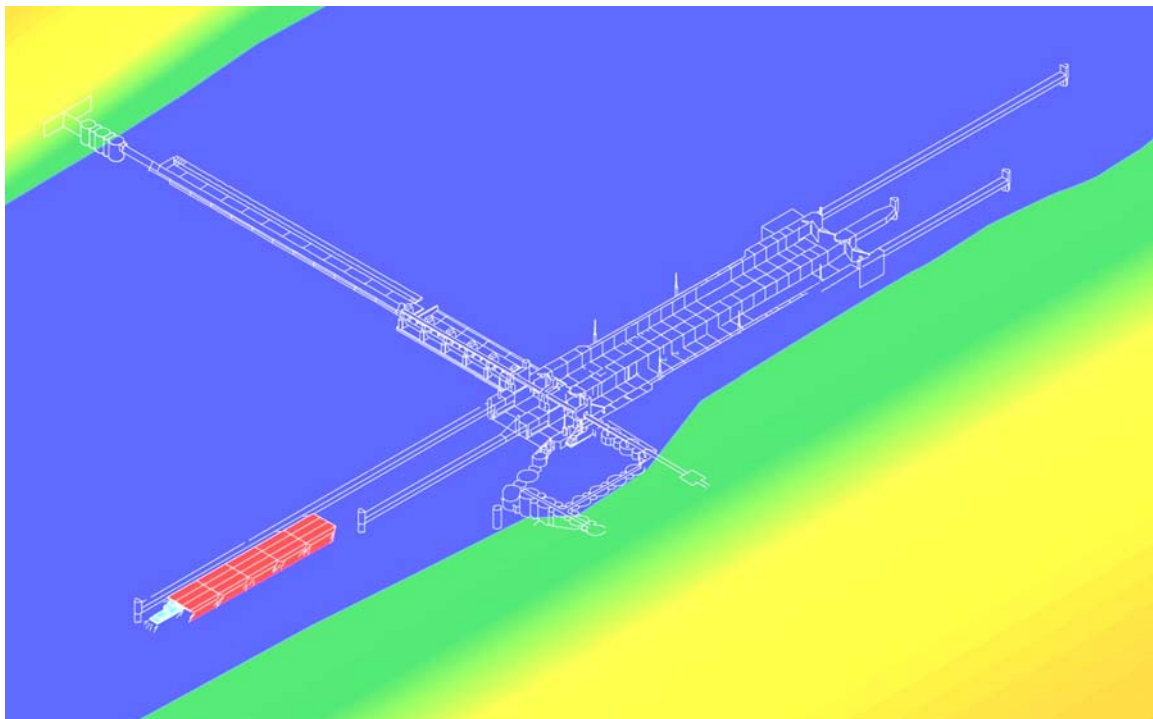
C-12. Olmsted Locks and Dam, Conceptual Construction Features

a. The Olmsted Locks and Dam Project (Figure C-16a) on the Ohio River is estimated to cost over one billion dollars. It will be the first locks and dam facility encountered when traveling upstream from the Mississippi River. The locks, with twin 3,936-m- (1,200-ft-) long chambers, were built within a sheet-pile cellular cofferdam, whereas both the approach walls and the dam are planned to be built using offsite prefabrication.

b. Figure C-16b illustrates how a catamaran crane barge can be used to install a precast concrete pier wall segment for Olmsted Dam. The pier wall segment is carried at the front of the crane barge to avoid interference with the previously built locks, which are not shown.

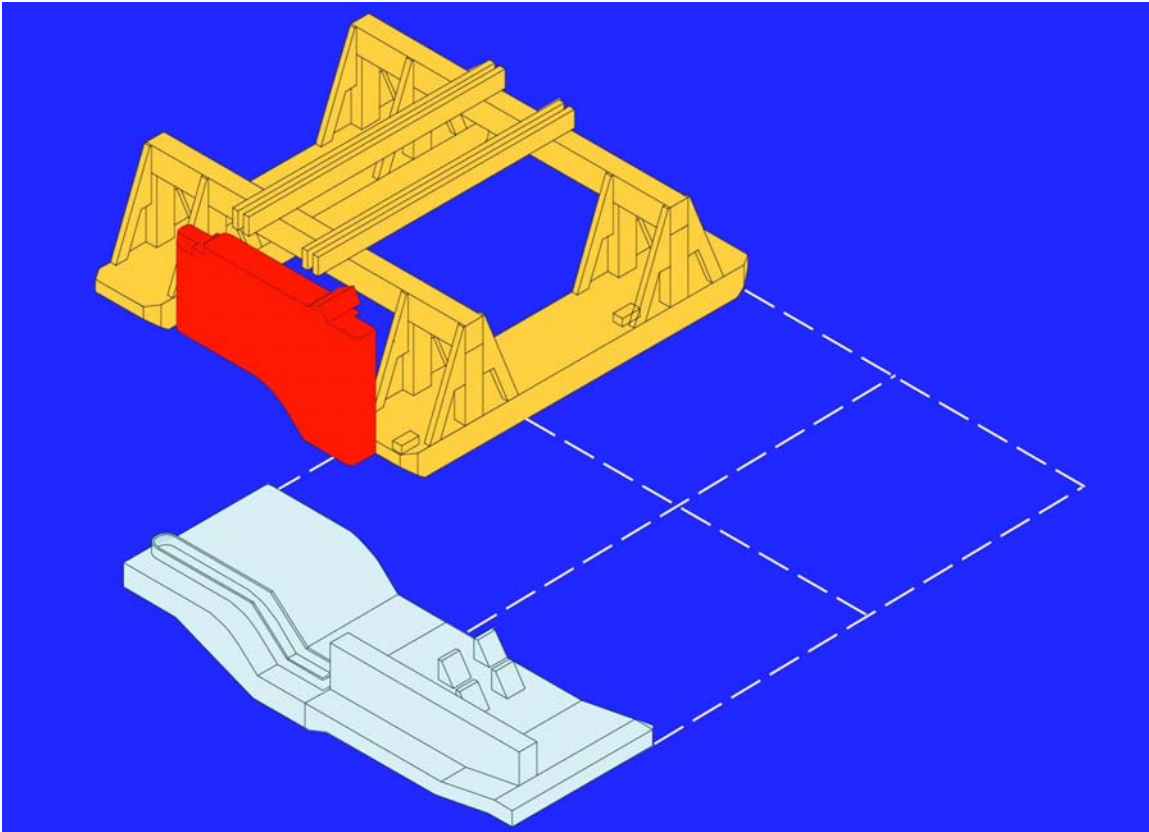
c. Figure C-16c illustrates several key aspects of a typical construction sequence for Olmsted Dam:

- Dredging and backfill operations are first executed for the sandy riverbed.
- The backfill is screeded to the appropriate tolerance.
- A mattress is then set down and piles are driven through it.
- Then, the shell is installed and tremied in place.

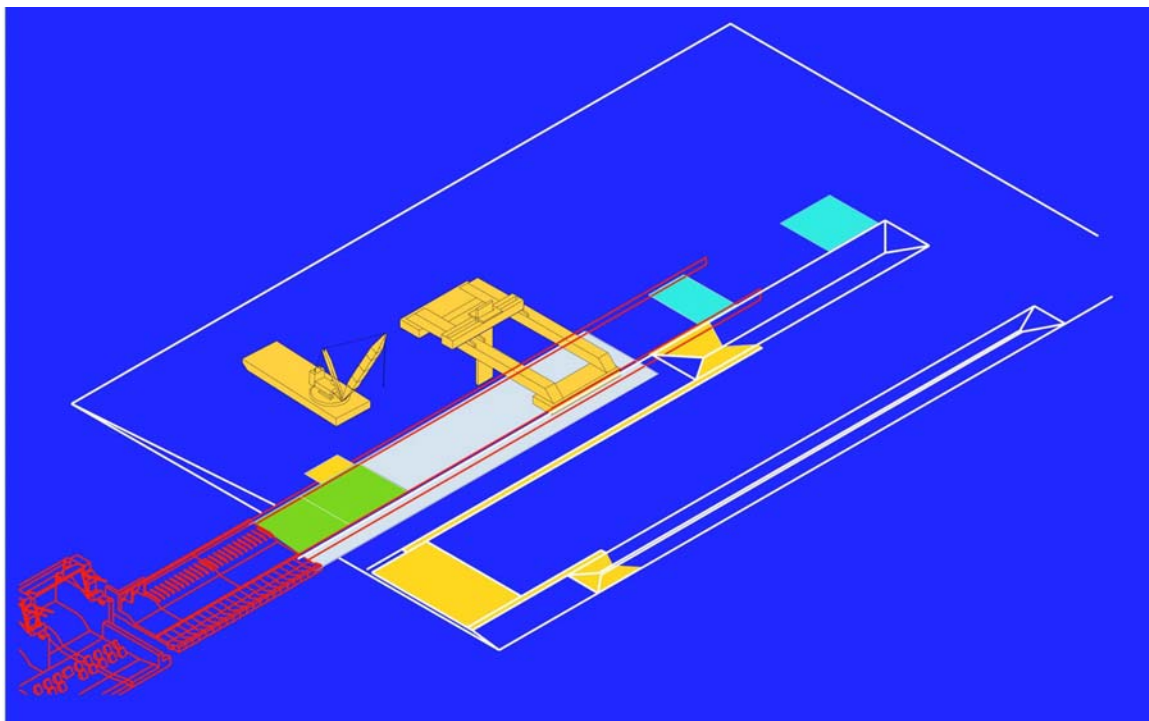


a. Representative overview

Figure C-16. Conceptual construction of Olmsted Locks and Dam, Ohio River (Continued)



b. Representation of the installation of a precast pier wall segment



c. Representation of the construction sequence for the navigable pass
Figure C-16. (Concluded)

C-13. Other Examples of Prefabricated Methods of Construction

Figures C-17 through C-22 illustrate projects that represent applications of the innovative construction methods described in this manual.

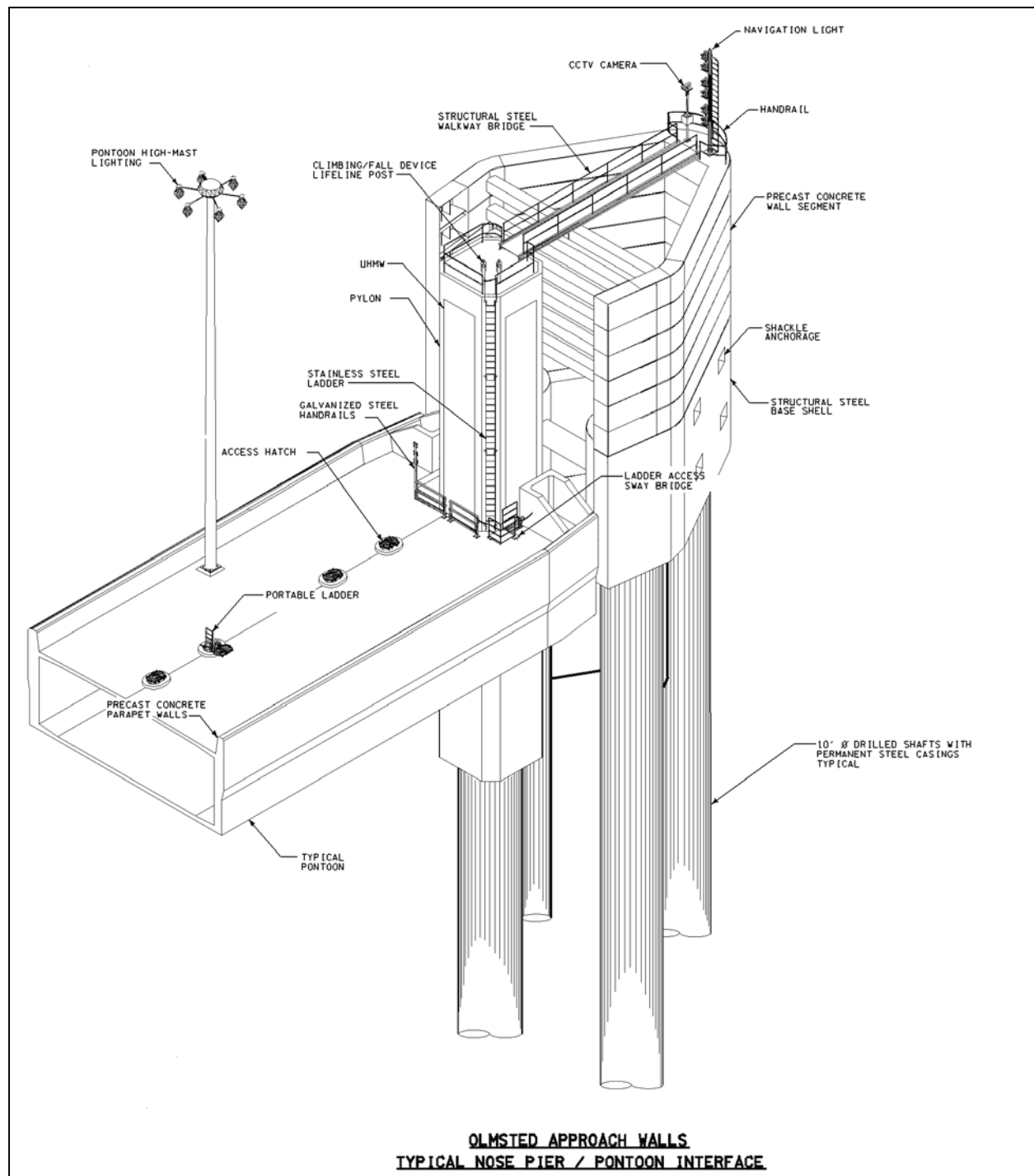


Figure C-17. Detail view of floating approach wall connection to nose pier, Olmsted approach walls. Approach wall is a hollow precast concrete shell fabricated offsite and connected to preinstalled piers

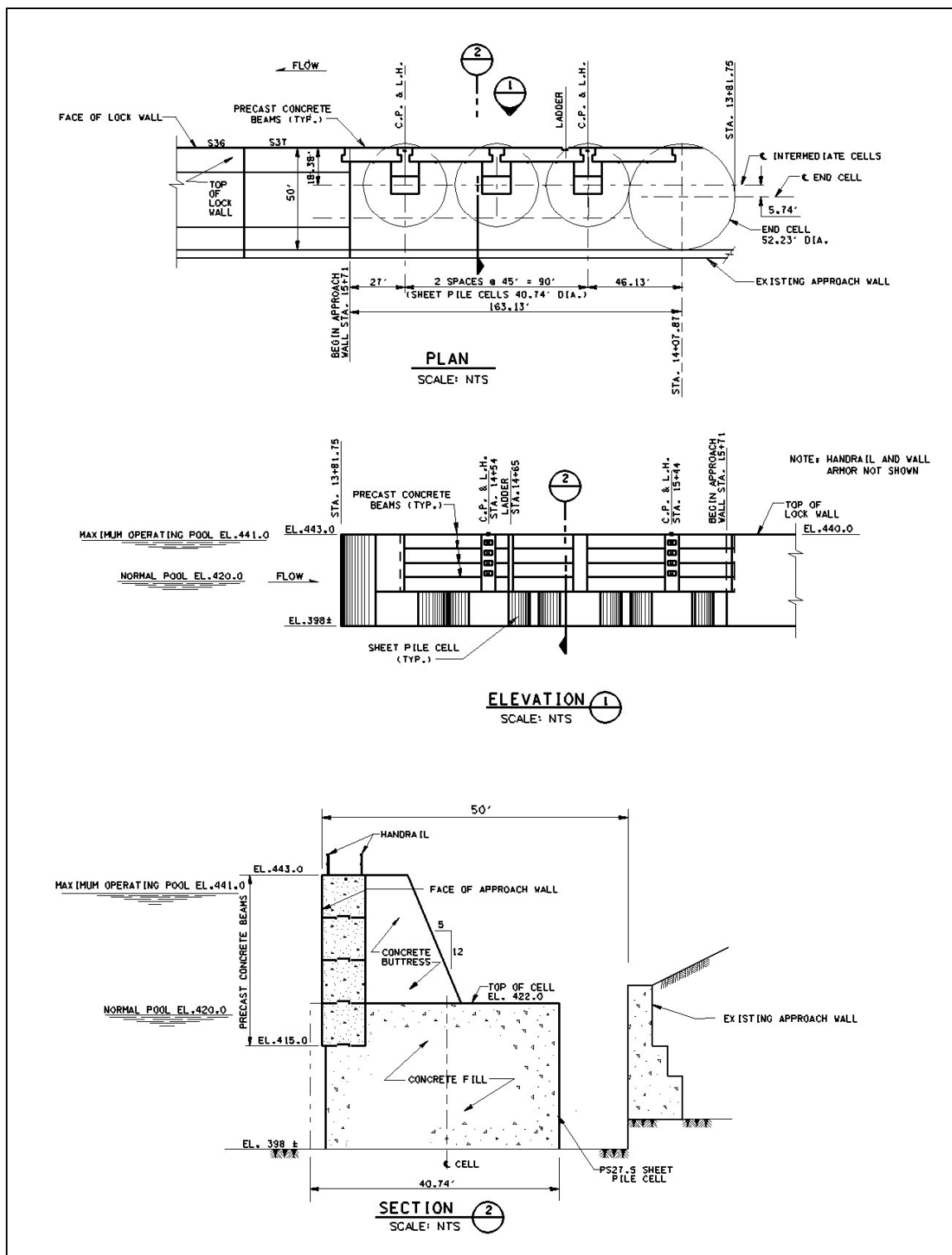


Figure C-18. McAlpine Lock upstream approach wall. Substructure is a concrete-filled sheet-pile cell founded on bedrock. The cell is installed in the wet and is outfitted to receive the first precast beam. The concrete buttress is built in the dry and transfers barge impact loads to the substructure

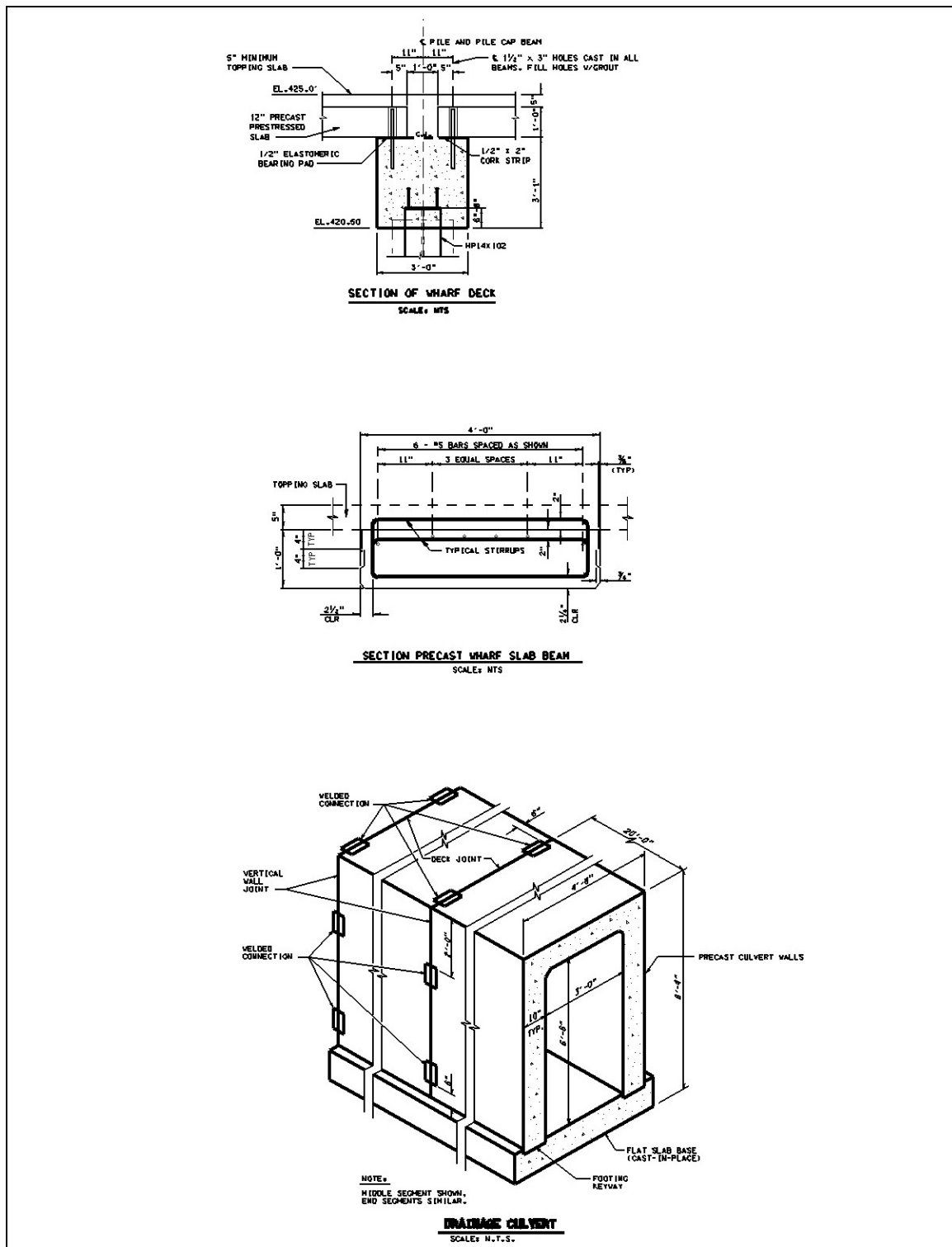


Figure C-19. McAlpine miscellaneous precast elements. Examples of other precast elements on McAlpine Lock

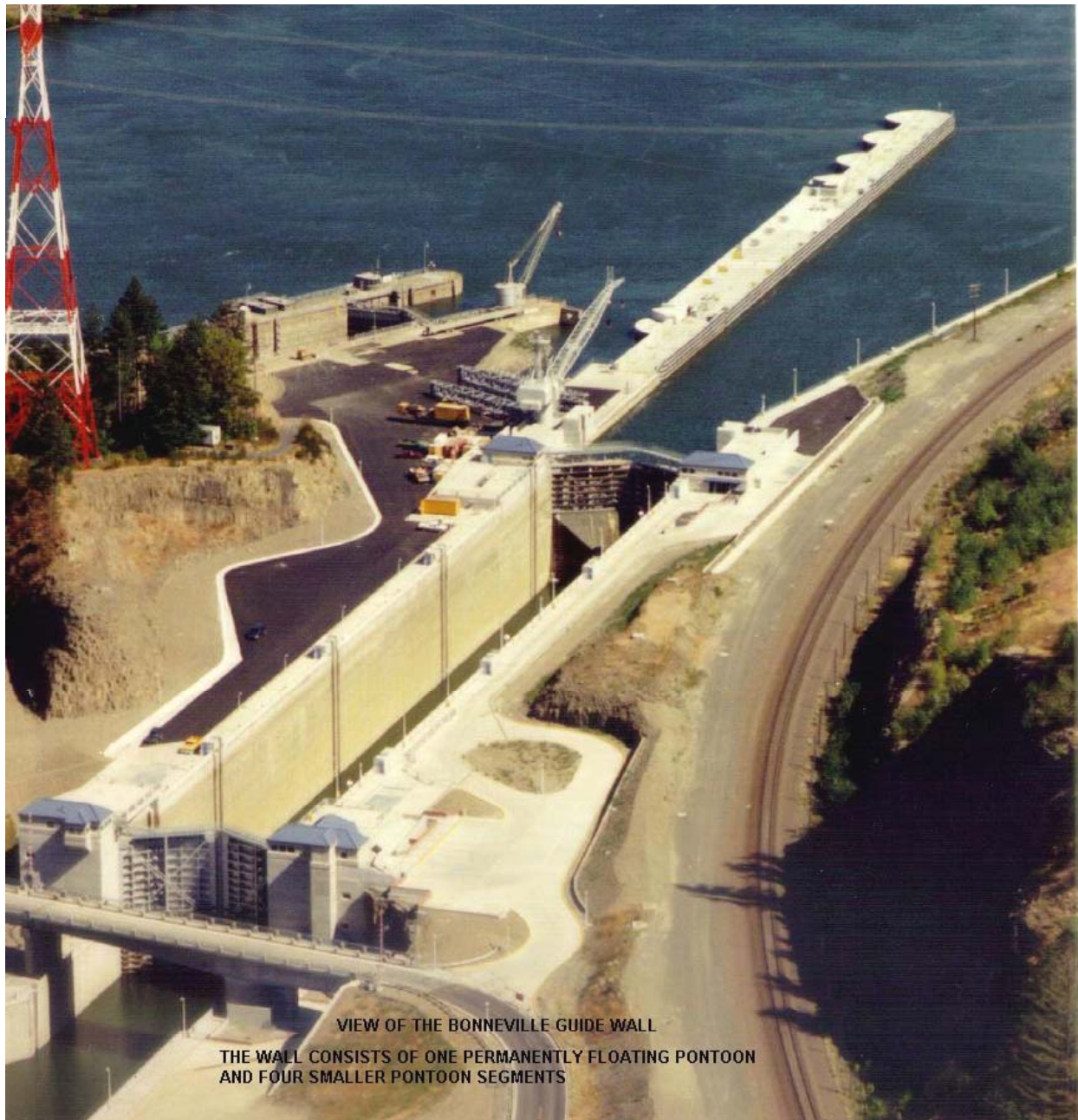


Figure C-20. General view of Bonneville Lock and floating upper approach wall



Figure C-21. Precast yard in Bordman, Oregon, for Bonneville Project. The contractor constructed a graving dock. The pontoons were fabricated, the site was flooded, and the pontoons were towed to Bonneville for installation

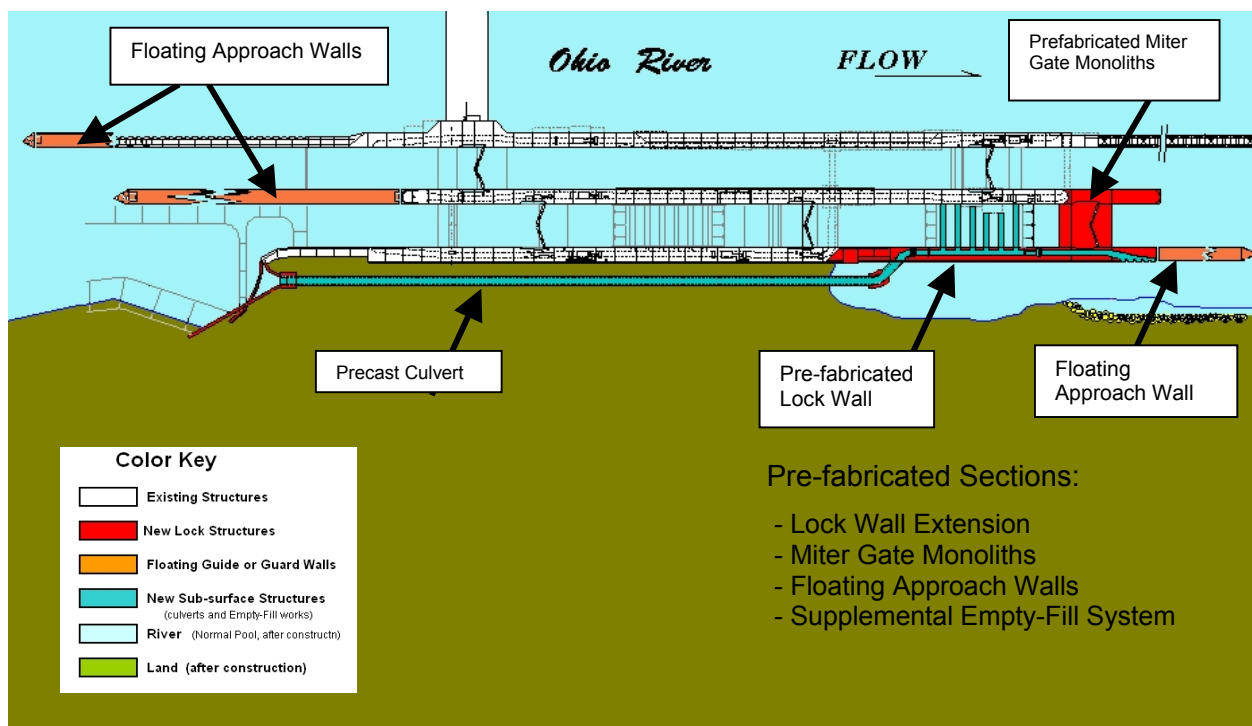


Figure C-22. Overview of prefabricated elements to be used for the Ohio River Main Stem Study